Natural Gas Infrastructure Reliability Industry Forums

Virtual Pipeline System Testbed to Optimize the U.S. Natural Gas Transmission Pipeline System

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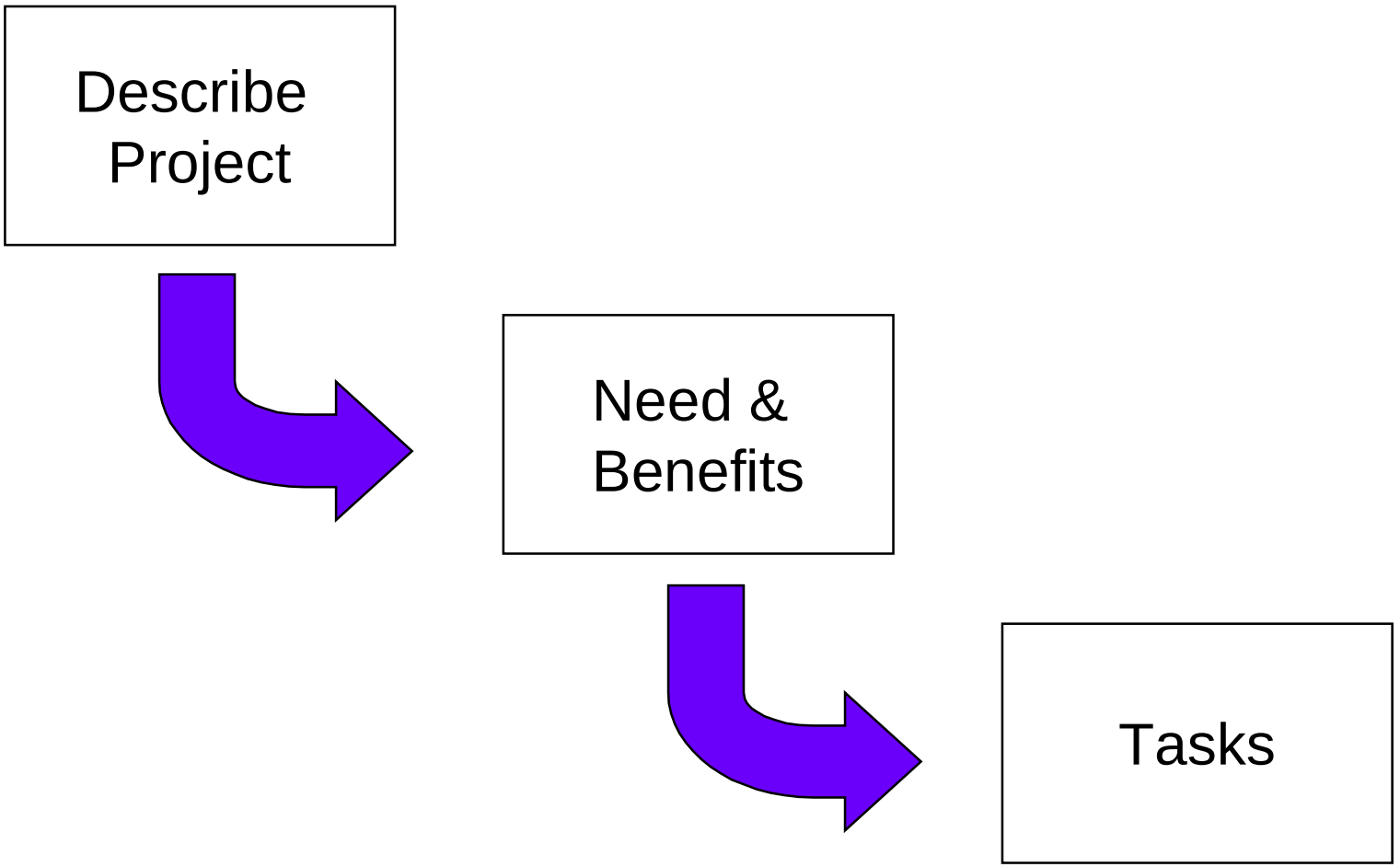
Agenda

- Review project intent, tasks, and objectives
- Progress to date
- Pipeline & Compressor Station Simulation Meeting at K-State
  - How are current software applications used?
  - Positives and negatives
  - Prioritize needs and features
  - Finalize key project outcomes critical to industry
- Next steps

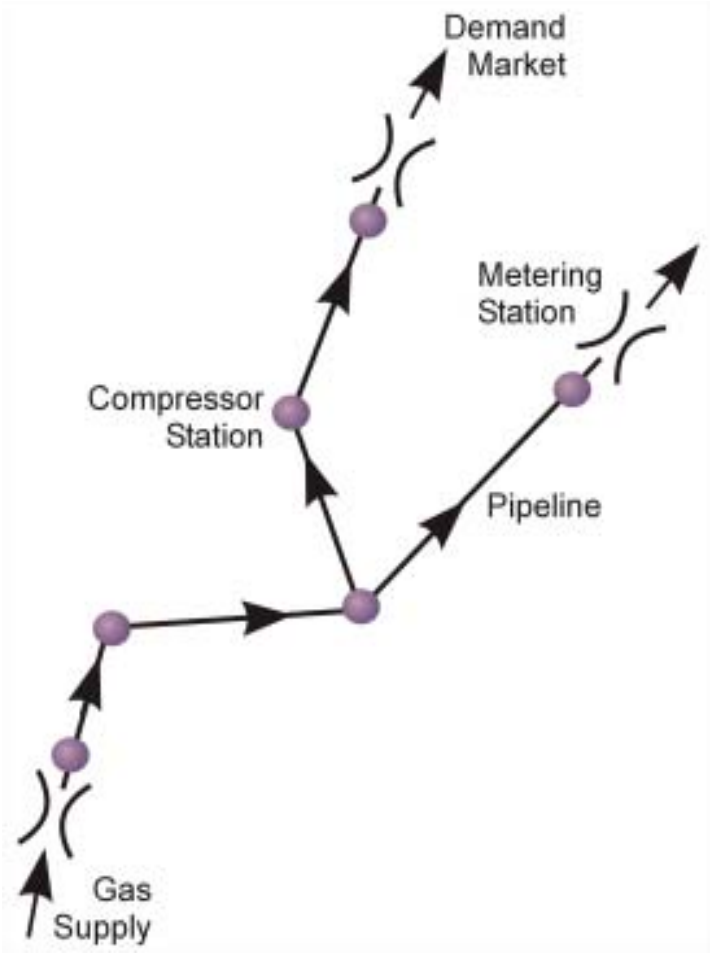
The Project…

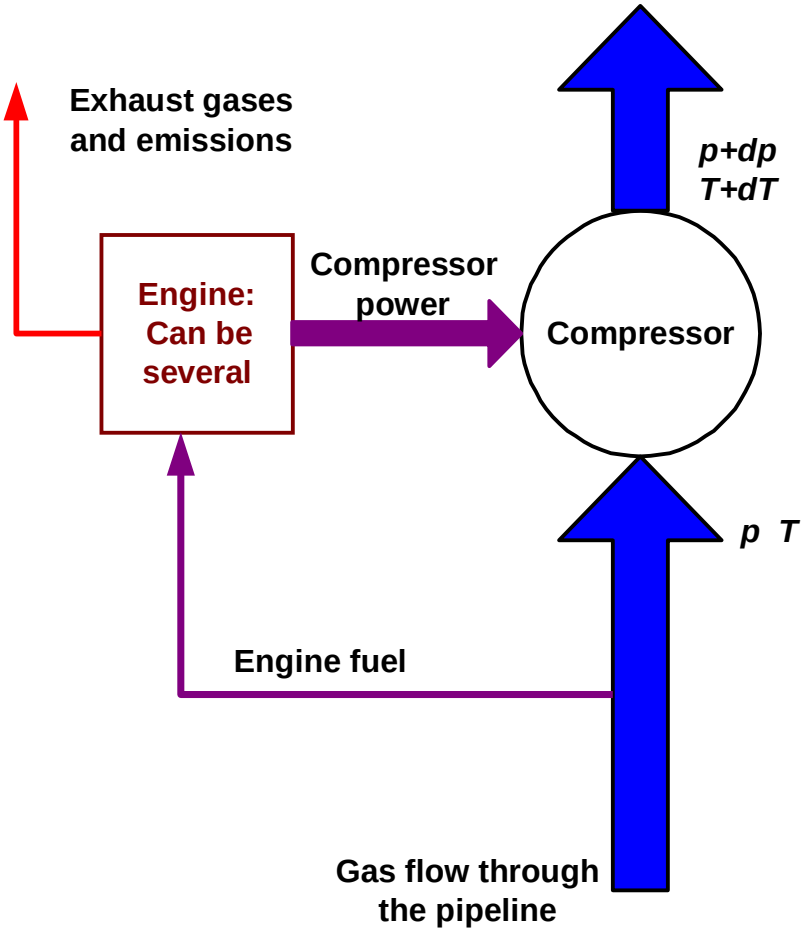


Project Objective

Develop and integrate
compressor station
and pipeline system component
computer models into the
Virtual Pipeline System Testbed

Pipeline Illustration





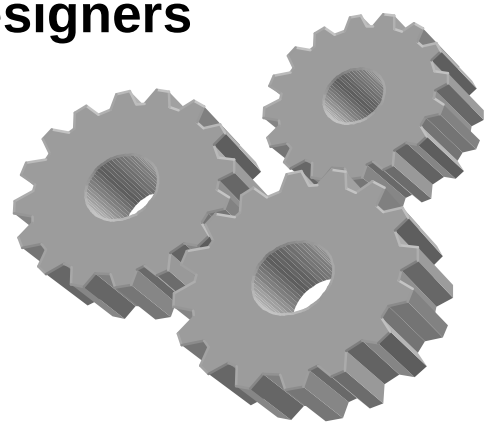
VPST Will Determine

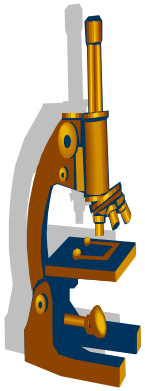
- System pressures and flow rates
- Pollutant emissions?
- Fuel consumed
- System line pack as function of time
  - Gas is compressible
  - Line pipe acts as a capacitor

VPST Users

Economists

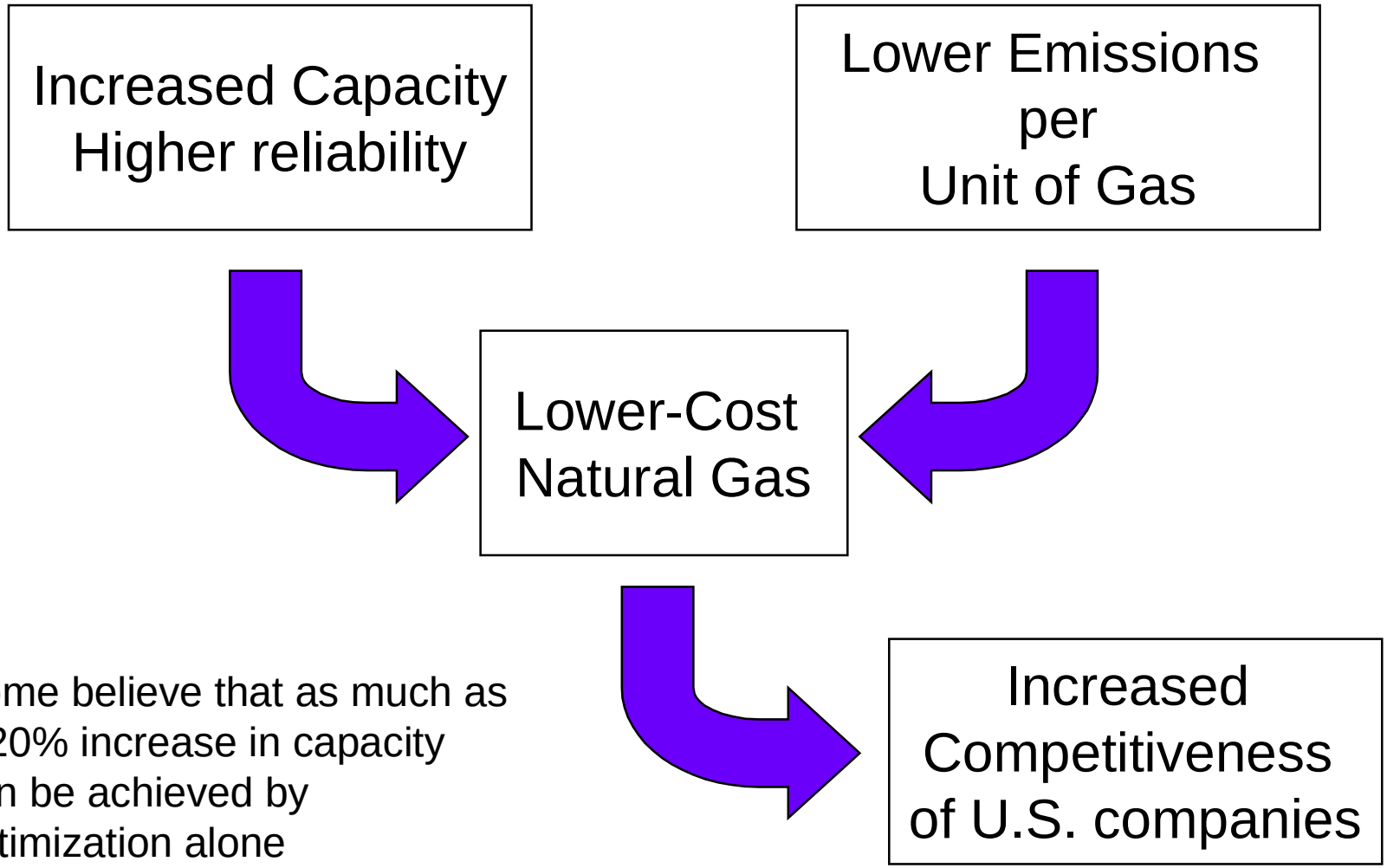
Reliability engineers
Pipeline operators
Pipeline designers





Researchers

Benefits



Some believe that as much as a 20% increase in capacity can be achieved by optimization alone

Previous Work

- Steady state simulations exist in the public domain and in private industry
- Dynamic simulations are few
- No dynamic simulation fully addresses the needs of pipeline operation
- Compressor station components need additional detail
- Complex input data for complex systems

Knowledge to be Gained

- Clear understanding of the interaction between pipeline components within the system
- Used to determine the impact of system changes on
  - Deliverability of gas
  - Environment
  - Safety and reliability
  - Pollutant emissions?

Tasks

1. Develop component models
2. Develop optimization algorithm
3. Software & hardware implementation
4. Develop control modules
5. Evaluate & analyze pipeline events

Task 1

VPST Integrated Components

- Compressor station
  - Reciprocating and gas turbine engines
  - Reciprocating and centrifugal compressors
  - Turbochargers
  - Others
- Pipe
- Gas supply sources
- Blocking valves
- Metering stations
- End-user demand markets

Task 2

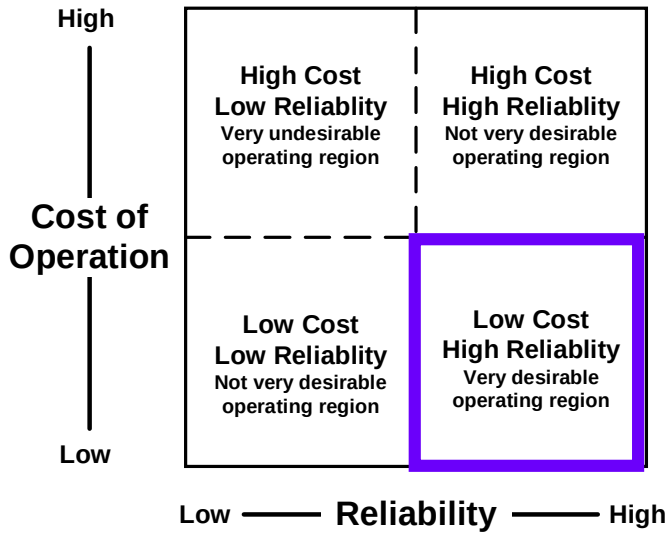
Optimization Algorithms

- Work conducted by Dr. Prakash Krishnaswami (mechanical engineer)
- Make decisions for new pipeline construction
- Determine operational rules to deliver gas in the most efficient/low cost and reliable path

Task 2

Robustly Design and Operate Optimization Strategy

- Balance reliability with cost
- Minimize impact of failures



Task 3

Computer Architecture & Solution Techniques

- Work conducted by Dr. Virgil Wallentine (computer scientist)
- Parallel computing
- Beowulf cluster of *shared memory* processors
- Graphical user interface where user will drag icons to desired location

Task 4

Control Model

- VPST compressor station node will be programmed with control logic to represent the suction/discharge pressure control strategy
- Additional ability to evaluate engine control systems
- Real-time control of pipeline?

Task 5

Demonstrate VPST

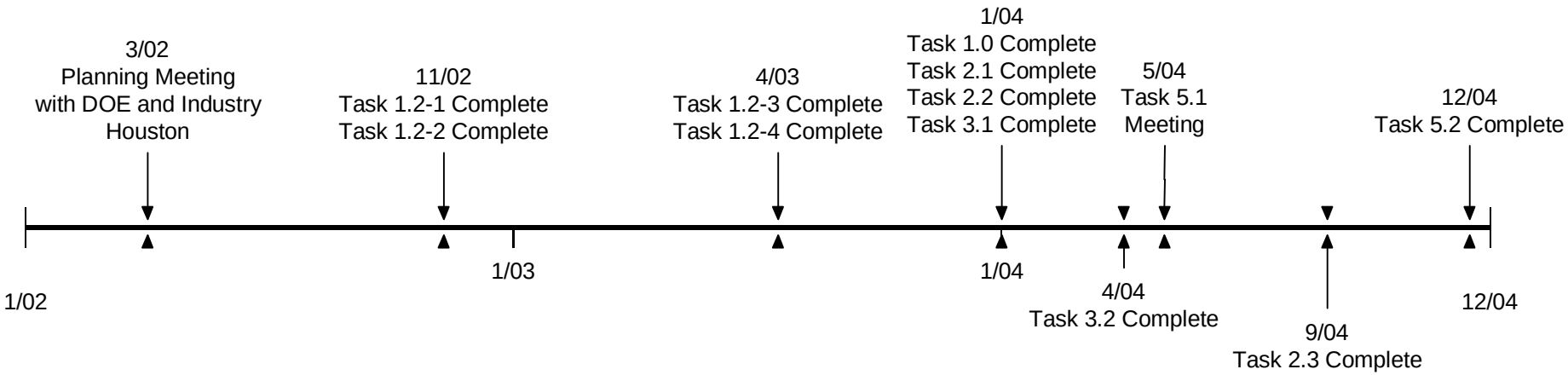
- “Base” pipeline system created with input from the industry
- Develop performance index
- Run VPST over a series of cases

Operational Examples

- Insert new ignition system on all engines in the system
- Replace horsepower with gas turbines
- Determine the most **reliable** and **efficient** way to deliver gas to a region
- Investigate the impact of control strategies
- Investigate the environmental impact of upgrading one particular compressor station in an entire system

Where we are today…

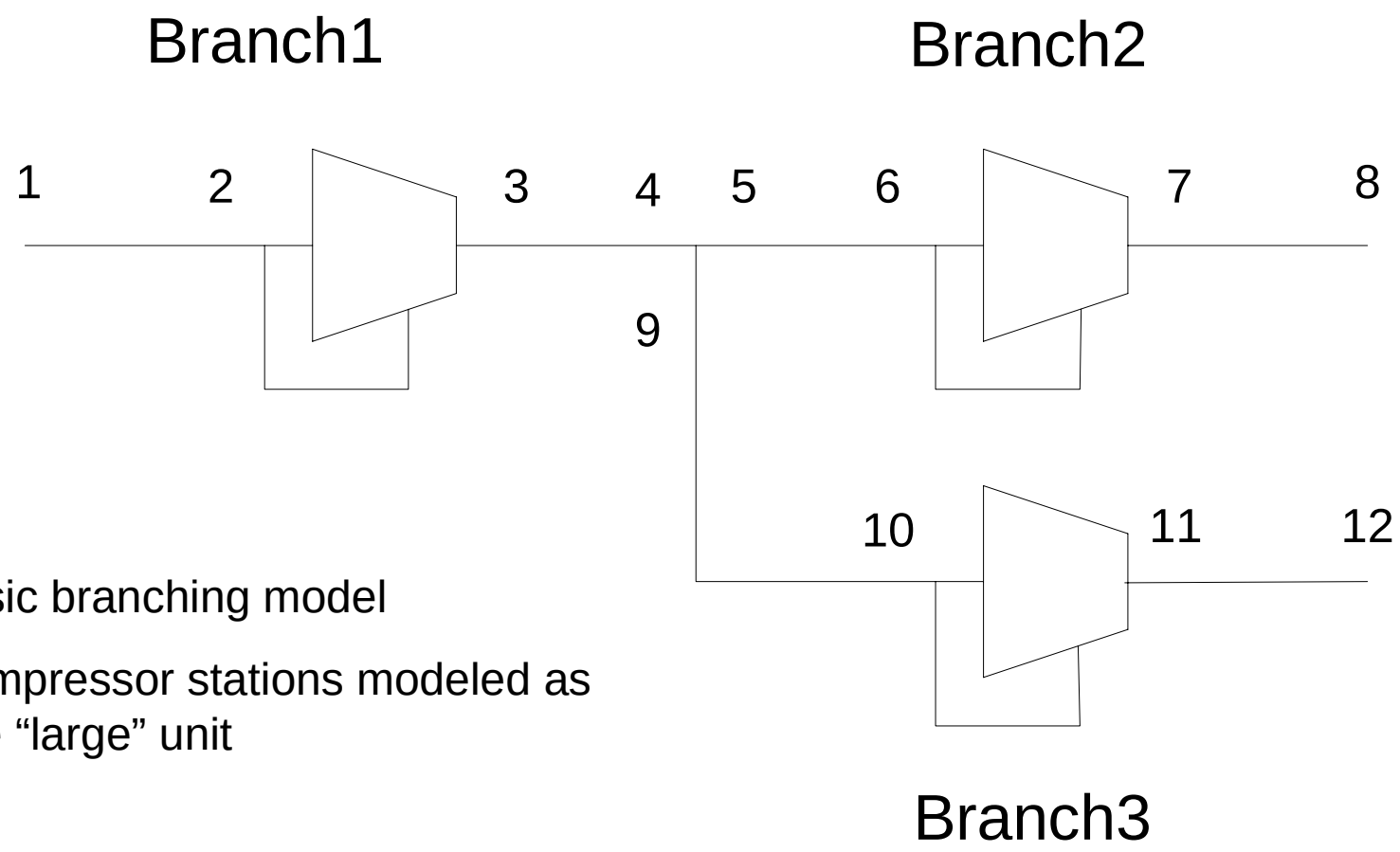
Major Milestones



Our Basic Attack

- Develop a basic “pipe” model
- Develop basic compressor station component models
- Test these models within the “pipe” model
- Enhance and increase sophistication of component models
  - Turbochargers
  - Engines
  - Filtration systems
  - Enhanced mixing

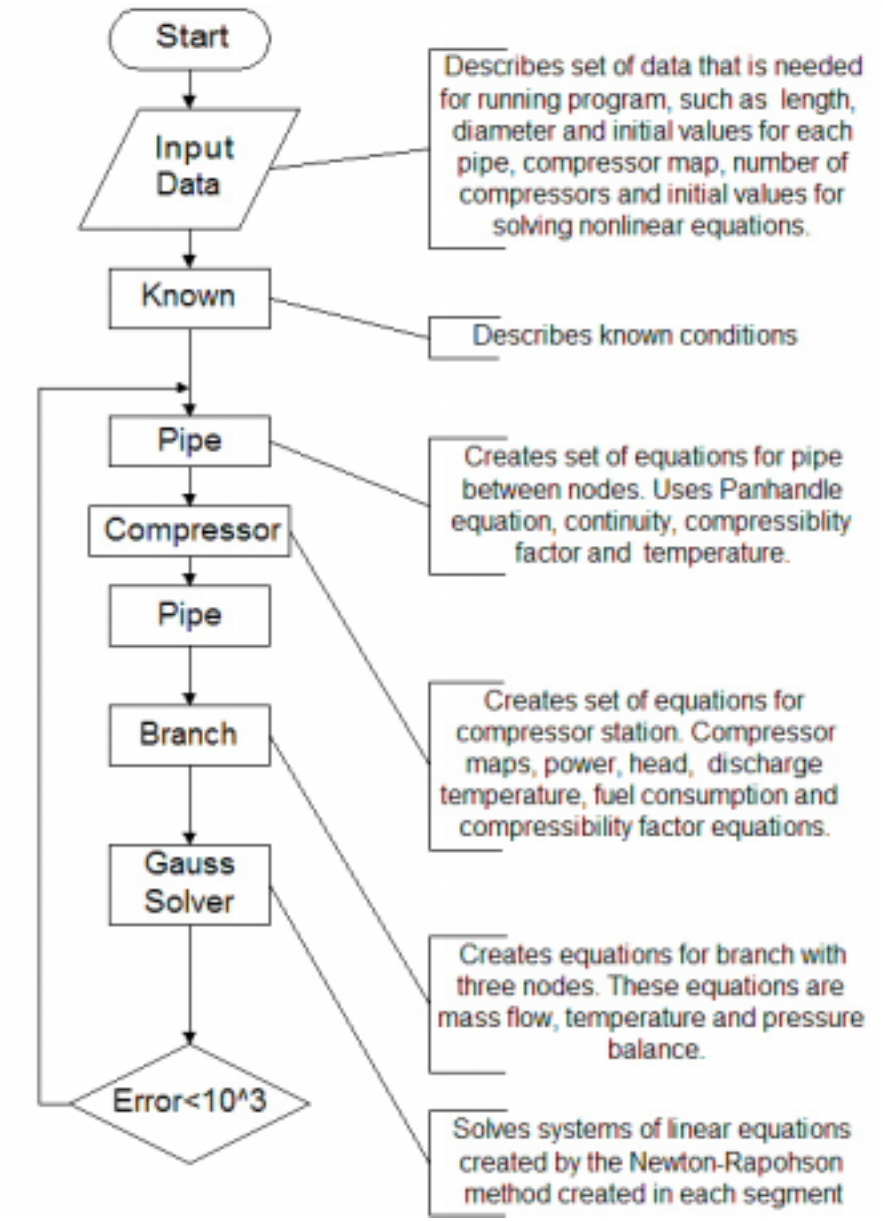
Our Basic "Pipe" Model



Basic branching model

Compressor stations modeled as one "large" unit

Program Flow Diagram



P&CSS Meeting at K-State

August 28, 2002

- Identify positives and negatives of existing pipeline simulation software
- Determine features and models that need to be developed to make existing software more useable and accurate
- Determine specific outcomes from the current DOE project that will be most useful to the industry

Attendees

- El Paso Corporation
  - ANR Pipeline
  - Tennessee Gas Pipeline
  - Colorado Interstate Pipeline
- Northern Natural Gas Pipeline
- Pipeline Research Council International
- Advanced Engine Technology Corporation
- Interested, but could not attend
  - Williams Pipeline
  - CMS Energy
  - NiSource

Meeting Format

- Identify how current software is used
- Discuss positives and negatives of current software
- Identify features that are missing
- Prioritize key features that are of the most benefit to the user community
- Follow-up plans

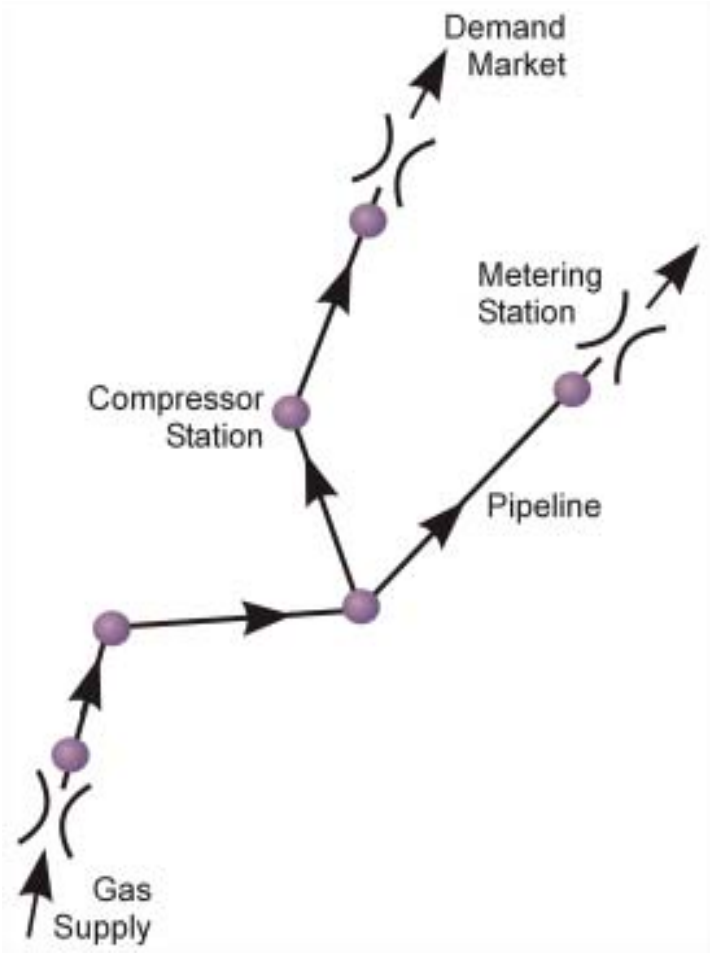
Software Vendors

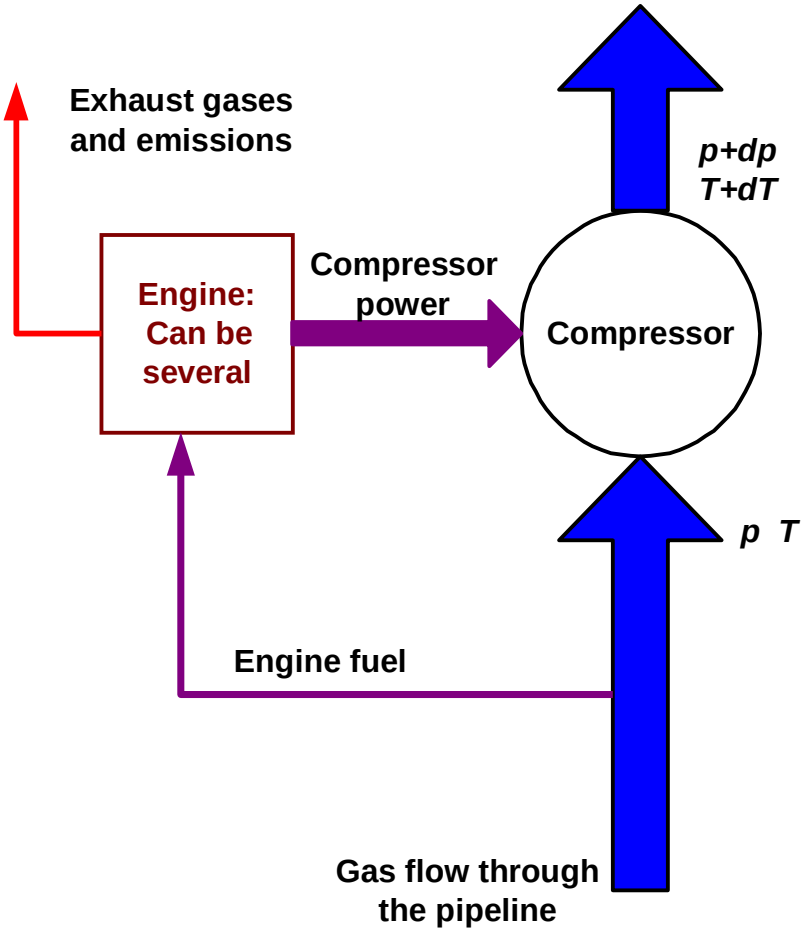
- Gregg Engineering
- Advantica-Stoner
- Energy Solutions, International
- Simulutions

Focus mostly on line pipe between compressor stations

- Others working on optimization
  - ProStrategic (previous work with airline industry)
  - Adaptive Trade

Pipeline Illustration





How Industry Uses Vendor Software

- Assess impact of storage on dynamic deliverability
- Determine quantity of extra available hp
- Evaluate operation and design
- Determine incremental hp necessary to overcome bottleneck
- Interface with SCADA systems to
  - Save fuel
  - Determine where and when maintenance is necessary

Potential Uses Not Currently Available

- Determine impact of “upset” conditions
- Expert system
  - Analyze data to see if system is operating at peak capacity
  - Diagnose compressor station problems
- Engine and compressor performance calculations are not standardized
- Individual compressor flow rate and the ability to map compressors in real-time
- Ambient de-rates and up-rates
- Engine startup and shutdown
- Impact of distributed power plants on interruptible gas supply
- **Compressor station simulation**

Recommended New Focus

- Focus on compressor station components
- Work with vendors so that K-State model would "hook" into vendor programs
- Expert system to help
  - Diagnose problems
  - Review data input from SCADA systems
  - Recognize when data is invalid
- Optimization
  - Cost of operating in the planning stage is based on fuel
  - Incorporate the impact of maintenance costs

Key Components

- Engines
- Turbines
- Compressors

Be able to mix and match. There are examples in the field of reciprocating engines driving centrifugal compressors

- Station yard piping – current losses may be more significant than originally thought
- Gas composition – not currently well-done in vendor software
- Scrubbers and filters – pressure drop can be high
- Gas coolers – may be able to get higher throughput

Next Steps

- Contact software vendors
  - Assure vendors that we are not creating a “freeware” competing product
  - Mike Goodman (El Paso) and Gary Choquette (Northern Natural) agreed to co-sign letter
  - Outline meeting outcomes
  - Ask for ability to “hook” into their software
- Presentation at Pipeline Simulation Interest Group meeting
  - Mike Goodman to request time slot
  - October 23-25
- Continue development of compressor station components

Thanks for your participation,
and the valuable assistance and feedback
from El Paso Corporation, Northern Natural Gas,
AETC, PRCI, and the DOE SCNG

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